Section 4 Genetics and heredity

Chapter 21 Cell division, chromosomes and genes

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1. **a** Gametes are reproductive cells.
   (i) Plants. The male gametes are the pollen nuclei and are produced in the anthers. The female gametes are the egg cells in the ovules which are produced by the ovary.
   (ii) Animals. The male gametes are the sperms which are produced in the testes. The female gametes are the ova which are produced in the ovaries.
   b At fertilisation the nucleus of the male gamete fuses with the nucleus of the female gamete.
   c A zygote is the cell formed from the fusion of the male and female gametes. It develops into an embryo.

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1. There will be 2 x 46 = 92 chromatids at this stage. (*See* p. 184).
2. The chromosomes are too thin to be seen by the light microscope.
3. Cells in the basal layer will be dividing and producing more epidermal cells. Mitosis will be taking place in these cells.
4. It is not possible to answer this question without more knowledge than is provided here.

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1. **a** 46 **b** 40 **c** 46.
2. 46.

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1. **a** human 23 **b** fruit fly 4.
2. White blood cell - diploid. Male cell in pollen grain - haploid. Guard cell - diploid. Root hair - diploid. Ovum - haploid. Sperm - haploid. Skin cell - diploid. Egg cell in ovule - haploid.
3. **a** testes **b** ovary **c** stamen and ovule.
4. **a** 20 **b** 20.
5. Asexual reproduction takes place by mitosis. The chromosomes in each cell and therefore in each individual are identical. There can be no variation..

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1. alanine - alanine - valine - glycine - valine.
2. CAT must have taken the place of the triplet CCA.
3. The gene determines the sequence of amino acids in the protein molecule which, in turn, forms the enzyme. The enzyme controls a certain chemical reaction in the cell which affects the cell’s structure.
4. Radiation causes an increase in mutation rate. If a mutation occurs in a gamete, it will affect the offspring.

Chapter 22 Heredity

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1. One possible choice is **T** for the dominant gene (allele) and **t** for the recessesive gene.
2. The chromosomes are in pairs (one from the male parent and one from the female parent) and so the genes they carry must be in pairs. If both genes are dominant or both recessive, they will control the characteristic in the same way. If one is recessive and one dominant they will not affect the characteristic in the same way.
3. Since the gene for black hair is dominant over the gene for red hair, the person would have black hair.
4. **a** For example: Gene for red hair **b**, gene for black hair **B**.
   Combination for red hair - **bb.**
   b You would expect a red-haired couple to breed true because they must both be **bb.**
   c A black-haired couple could have a red-haired baby if they were both **Bb**.
5. **Aa** is heterozygous, **AA** is homozygous dominant, **aa** is homozygous recessive.
6. The gene for red, e.g. **R** is dominant over the gene for white **r**.

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1. All the offspring must inherit one gene from the male parent and one from the female parent so all the offspring must be **Bb**.
2. Only the **BB** mice will be true-breeding, i.e. one in three.
3. If white babies turn up in the second generation it means that one of the original parents must have been heterozygous **Bb**. (If both original parents were heterozygous you would expect some white offspring in the first generation).

The probable genotypes of this first generation will be **BB Bb BB Bb** (all black, but 50% homozygotes and 50% heterozygotes).

If the **BB** black guinea pigs are mated with **bb** white guinea pigs all their offspring will be **Bb** black guinea pigs.

If the **Bb** black guinea pigs are mated with **bb** white guinea pigs you would expect half of their offspring to be **Bb** guinea pigs. Adding these results together gives one half black and the other half with equal numbers of black and white offspring.

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1. (left hand column) You would carry out a recessive test-cross. Each parent would be mated with a homozygous white rabbit. With the homozygous parent this would produce all black offspring but with the heterozygous parent there would be, on average, 50% black heterozygous and 50% white homozygous babies.

1. (right hand column) If both parents are homozygous AA x BB, the children will be Group AB**.**
If the mother was heterozygous (AO) the children could be AB or B (AB or BO). If the father was heterozygous (BO) the children could be AB or A (AB or AO).
If both parents were heterozygous (AO, BO) the offspring could include groups A (AO), B (BO), AB or O.

2. The man cannot be the father. The genes for groups A and B are dominant to O. So whether the woman is homozygous or heterozygous for the A gene, the offspring would have received a dominant A or B gene.
If the father was heterozygous for the B gene (BO) and the woman was heterozygous for the A gene (AO) the child could have inherited two O genes.

3. **a** The alleles for red and white hairs are codominant
b

	W	R
W	WW	R
R	R	RR

On average, there would be a ratio of one red (RR), one white (WW) and two roan (RW) in a succession of calves

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1. The process of meiosis rules out the possibility of X sperms only. There will be an equal number of X and Y sperms in the father's semen. There is a 50:50 chance of an XY or XX zygote. But this is indeed a matter of chance, and the sequence of 4 girls is due to chance alone.

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1. The genotype for a woman with sickle-cell trait would be $\mathbf{HB^{a}Hb^{s}}$. If she
   a marries a normal man, whose genome would be $\mathbf{Hb^{a}Hb^{a}}$, none of the children would have the disease but half of them could inherit the trait.
   b marries a man with sickle cell trait, there is a 1in 4 chance that a child would be normal, a 1 in 4 chance that a child will have the disease and a 1 in 2 chance that the child will have the trait.
   c marries a man with sickle cell disease ($\mathbf{Hb^{s}Hb^{s}}$) two children in 4 could inherit the disease and 2 children in 4 could inherit the trait.

Chapter 23 Variation, selection and evolution

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1. **a** Mainly inherited; facial features, ability to talk.
   b Mainly acquired; manual skills, language.
   c More or less equal mixture: body build, athleticism.
2. **a** The X and Y sex chromosomes are inherited independently of hair colour and texture. So whereas the father has brown eyes and straight hair, his sons could have blue eyes and straight hair. Similarly the mother has blue eyes and curly hair but her daughters could inherit brown eyes and curly hair.
   b The children would all have brown curly hair, unlike either of their parents.

3. Tall plant with yellow seeds **TtYy.** Dwarf plant with green seeds. **ttyy**

Gametes	TY	Ty	tY	ty
ty	TtYy	Ttyy	ttYy	ttyy

There are two new combinations of characters: tall plants with green seeds (**Ttyy**) and dwarf plants with yellow seeds (**ttYy**)

4. The apples on the south side will receive slightly more sunlight than those on the north side. So photosynthesis will be greater and, consequently, the fruit will be larger.
The apple leaves on the lower branches will be shaded by the foliage above and so receive less sunlight that those in the upper branches. The apples on the north side lower branches will receive least sunlight.
5. **A** will now be on the same chromosome as **b** and **c** so **Abc** will be a new combination. So will **aBC**.

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1. Assuming that it is the male who is competing, his plumage might be brighter and his song louder that his rivals. He might also be more aggressive towards his competitors, so leaving him space to attract a female. He might also have a more striking display pattern.
2. Selection pressures might include: drought or excessive rainfall, very high or very low temperatures, the growth rate of competing plants, the stresses of being walked on, pattern of light and shade, good or poor drainage, availability of mineral ions in the soil. The plants which are able to cope with these pressures are the ones most likely to survive and reproduce.

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1. The amphibia were most abundant in the Permian and Triassic periods 200 million years ago.
2. The features which suggest relationship with present-day fish are the shape of the body, scales, a tail fin and what looks like a gill opening.
3. The positions in the evolutionary tree diagram reflect the complexity of the organism and the time of appearance in the course of evolution. Worms and insects are complex organisms but not so complex as birds and mammals. Worms and insects of one kind or another appear early on in the fossil record. Birds and mammals are comparatively recent 'arrivals'.

Chapter 24 Applied genetics

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1. Good characteristics could include: fertility, growth rate, disease resistance, wool texture, wool length.
2. The plant breeder would be begin by crossing the two varieties. The outcome would depend on which of the genes were dominant and which recessive. (In fact it would almost certainly be a group of genes for each characteristic). Assuming that the long stalk gene (**L**) and the good ear genes (**G**) are dominant, the genotypes **LLgg** and **llGG** would produce **LlGg** offspring, which would combine both desirable characteristics but would not breed true. If the parents were heterozygous for the dominant gene **Llgg** and **llGg.** There would still be desirable combinations of **L** and **G** among the offspring but in much smaller numbers (one in four).
3. The F_1 seeds will be heterozygous for the desirable characteristics and will not breed true.

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1. **a** The substrate for a restriction enzyme is DNA.
 b The particular substrate for a restriction enzyme will be the link between two specific DNA triplets.
2 The vectors might be plasmids, viruses, bacteria or liposomes.
3. **a** Insulin extracted from cattle or pigs may carry ‘foreign’ proteins which provoke an allergic reaction. Genetically engineered insulin does not contain these proteins.
 b Genetically produced chymosin does not depend on an animal source where the supply may be inconsistent. It is purer than the chymosin produced from calves’ stomachs.
4. The principle is to replace a defective gene with a healthy gene.
5. Viruses could reproduce in the host and cause disease. The viruses have to be ‘disabled’ so that they cannot reproduce.
6. Unless it can be shown that using sheep to produce drugs causes their suffering, it is hard to think of any reasonable ethical objections.
7. **a** The potential benefits are that GM crops could withstand drought, grow in saline conditions, carry resistance to pests and diseases, have higher yields, produce additional vitamins.
 b The potential hazards are that genetically engineered plants could escape into the environment or exchange their modified genes with wild plants. This is only a hazard if the engineered genes confer resistance to a herbicide or cause the plants to produce compounds which could be harmful to other organisms.
8. Animals in a clone will all have the same genotype and will be identical. Animals produced by sexual reproduction will show variation.
9. Stem cells retain their ability to divide and produce new cells. A zygote can divide and produce all the cells in the body. In this respect it is acting as a stem cell.
10**. a** Restriction fragments are short lengths of DNA produced by restriction enzymes.
 b The restriction fragments differ in length.
 c The fragments can be separated by placing the sample at one end of a gelatine sheet and applying an electric current which causes the fragments to separate by distances related to their length.